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[19] **RU** [11] Pat. No.: **2057914** [13] **C1**
[51] Int. Cl. 6 E 21 B 43 / 22

Russian Federation Committee on Patents and Trademarks

[12] # Description of Invention
for a Russian Federation Patent

[21]	Appl. No.:	93025218/03
[22]	Filed:	April 27, 1993
[46]		April 10, 1996, Bulletin no. 10
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[56]	References Cited:	1. US patent no. 3412792, cl. 166-9, 1968. 2. USSR Inventor's Certificate no. 1682539, Int.Cl. E 21B 43/22, 1991.

[54] Method of crude oil production
[54] Sposob dobychi nefti
[57] Abstract

The method of crude oil production comprises injecting a formation with a dispersion of solid particles in an aqueous polymer or alkaline solution in which wood powder is used as for the solid particles. The quantity of wood powder used is 0.3 - 1.5% of the total mass of the dispersion. Polyacrylamide or polyoxyethylene[1] or carboxymethyl cellulose is used as the polymer, in a concentration of 0.005 - 1.0%. Sodium hydroxide or sodium silicate or potassium hydroxide is used as the alkali, in a concentration of 0.05 - 20.0%. 3 dependent claims, 2 tables.

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[1] The Russian has *polioksielement*, literally "polyoxyelement"; however, this appears to be a typo here for Russian *polioksietilen* "polyoxyethylene", which is used throughout the rest of the patent — translator.

The invention concerns the oil producing industry, in particular methods of producing crude oil by water flooding.

A method is known of producing oil which comprises injecting the formation with a dispersion of solid particles ($CaCO_3$) in an aqueous solution of a surfactant [1]. The shortcoming of this method is its low efficiency, which is caused by the insignificant water-isolating capacity of the dispersion due to the lack of swelling and low sedimentation stability of the salts, which are not dissolved in the water.

The method of producing crude oil whose technical essence and results are closest to those of the invention is that which comprises injecting the formation with a dispersion of solid particles with a polymer in an aqueous solution of a surfactant [2]. The shortcoming of this method is its low efficiency, which is caused by the inadequate water isolating capacity due to the low residual flow resistance factor created by the system produced in the formation due to its swelling and low sedimentation stability.

The basic task of this invention was to create an effective method of producing crude oil from formations with different permeabilities.

The proposed method of producing crude oil comprises injecting the formation with wood powder in an aqueous polymer or alkaline solution, an advantageous variant having wood powder in an amount constituting 0.3 - 1.5% of the total mass of the dispersion.

Polyacrylamide or carboxymethyl cellulose or polyoxyethylene is used as the polymer, in a concentation of 0.005 - 1.0%.

Sodium hydroxide or sodium silicate or potassium hydroxide is used as the alkali, in a concentration of 0.05 - 20.0%.

As a result of being injected into the formation, the dispersion of wood powder in an aqueous polymer or alkaline solution advances through the washed, highly permeable zones of the formation. As the particles of wood powder advance, they gradually swell up.

The fact that the suspension is in an aqueous polymer or alkaline solution increases its sedimentation stability, as a result of which the wood powder penetrates deeper into the formation, and in the process of swelling the particles of wood powder attain dimensions comparable with those of the pores and attach to the porous medium and block water-saturated highly permeable zones of the formation from the penetration of subsequently injected water, changing its direction.

In order to prove that the invention in this application satisfies the criterion of "industrial usefulness", we shall describe an implementation of the method.

Under field conditions, the method is implemented by injecting a water-cut formation with a dispersion of wood powder in an aqueous polymer solution or an aqueous alkaline solution. The volume of the suspension injected is determined for each specific well on the basis of the characteristics of operation of the formation according to data of field investigations, and is checked by the intake capacity of the well.

An evaluation of the efficiency of the invention in this application and the method according to the prototype is made under laboratory conditions according to the following indicators: the degree of swelling, the sedimentation stability of the dispersed particles, and the residual flow resistance factor created by the systems produced in the formation.

Sedimentation stability is evaluated by the sedimentation time of solid particles in the investigated solutions, and the degree of swelling by the change in the volumes of solid particles before and after being treated with surfactant solution, polymer, and alkali.

Table 1 gives the results of the investigations.

Example 1 (prototype). Investigation of the degree of swelling and sedimentation stability of calcium carbonate particles in an aqueous surfactant and polymer solution. Calcium carbonate particles do not swell, and their sedimentation time is 2 minutes (see Table 1, experiment 1).

Example 2 (proposed method). Investigation of the degree of swelling and sedimentation stability of wood powder particles constituting 2% of the total mass of the dispersion in an aqueous solution of polyacrylamide, polyoxyethylene, and carboxymethyl cellulose (see Table 1, experiments 2, 3, and 4).

Example 3. Investigation of the degree of swelling and the sedimentation stability of wood powder particles in an aqueous alkaline solution of sodium hydroxide, sodium silicate, and potassium hydroxide (see Table 1, experiments 5, 6, and 7).

As the results of the investigations show, the stability of the wood powder particles sharply increases over that of calcium carbonate, and their degree of swelling is 140 - 148% in an aqueous polymer solution and 180 - 240% in aqueous alkaline solution, while the calcium carbonate particles do not swell up at all.

The residual flow resistance factor is determined by filtering the dispersion of solid particles through models of a fractured-porous-cavernous formation, represented by quartz sand having permeability of 7 - 43 μm^2. The water-saturated model is prepared by injecting three pore volumes of water at constant pressure until there is outflow at a steady state of filtration, and the filtration time of a unit volume of water τ_w is recorded. The model of the formation is injected, until there is a steady state of filtration, with around three pore volumes of the investigated dispersion of calcium carbonate in aqueous surfactant and

polymer solution, and [with around three pore volumes][2] of the dispersion of wood powder in an aqueous polymer or alkaline solution, and the filtration time is recorded for a unit volume of the injected liquid (τ).

The residual flow resistance factor of each fluid is determined according to the formula:

$$R_{res} = \frac{\tau}{\tau_w}$$

The magnitude of R_{res} is used to judge the isolating properties of the systems produced: the greater R_{res}, the higher their isolating property, and consequently, the more effective the crude oil production method is.

Table 2 shows the results of the investigations.

Example 4 (prototype). Determination of the residual flow resistance factor for injecting a dispersion of calcium carbonate in an aqueous surfactant and polymer solution; R_{res} is 2.9 (see Table 2, experiment 1).

Example 5 (method of the application). Determination of the residual flow resistance factor for injecting a dispersion of wood powder in an aqueous polyacrylamide solution; R_{res} is 6.2 (see Table 2, experiment 2).

Table 2 also gives the results of a determination of the residual flow resistance factor for injecting a dispersion of wood powder in aqueous solutions of polyoxyethylene, carboxymethyl cellulose, sodium hydroxide, sodium silicate, and potassium hydroxide at various concentrations (see Table 2, experiments 7-33).

As the data of Table 2 show, the residual flow resistance factor for the proposed method increases from 2.9 to 4.2-6.5.

Compared with the known method, the proposed method allows:

- increasing the efficiency of the method by increasing the residual flow resistance factor from 2.9 to 4.2-6.5;
- producing additional crude oil from each well-operation.

[2] The words in square brackets are not in the Russian and are added for clarity — translator.

Table 1

Exp. no.	Chemical reagent, aqueous solution	Concentration of chemical reagent (%)	Concentration of dispersed particles (%)	Sedimentation time (min.)	Degree of swelling (%)
Known method					
1.	Polymer + surfactant	0.01 0.5	$CaCO_3$ 0.1	2	0
Proposed method					
2.	Polyacrylamide		wood powder		
		0.001	2.0	3	142
		0.005	2.0	5	142
		0.010	2.0	23	142
		0.050	2.0	25	142
		0.100	2.0	(practically	142
		0.500	2.0	does not sedi-	142
		1.000	2.0	ment)	146
		1.200	2.0	-"-	146
		1.500	2.0		146
3.	Polyoxyethylene				
		0.001	2.0	2	140
		0.005	2.0	4	140
		0.010	2.0	4	140
		0.050	2.0	4	140
		0.100	2.0	7	145
		0.500	2.0	30	145
		1.000	2.0	does not sedi-	148
		1.200	2.0	ment	148
		1.500	2.0	-"-	148
4.	Carboxymethyl cellulose				
		0.001	2.0	2	140
		0.005	2.0	4	140
		0.010	2.0	4	140
		0.050	2.0	4	140
		0.100	2.0	5	140
		0.500	2.0	10	140
		1.000	2.0	25	140
		1.200	2.0	does not sedi-	140
		1.500	2.0	ment	140
5.	Sodium hydroxide				
		0.010	2.0	2	180
		0.050	2.0	3	195
		0.100	2.0	3	200
		1.000	2.0	4	200
		3.000	2.0	14	210
		5.000	2.0	18	210
		10.000	2.0	27	235
		20.000	2.0	35	235
		25.000	2.0	35	240
6.	Sodium silicate				
		0.010	2.0	2.0	190
		0.050	2.0	3.0	190
		1.000	2.0	3.5	190
		5.000	2.0	3.5	190
		10.000	2.0	7.0	190
		15.000	2.0	10.0	200
		20.000	2.0	18.0	200
		25.000	2.0	18.0	210
7.	Sodium hydroxide				
		0.010	2.0	4.0	170
		0.050	2.0	5.0	192
		10.000	2.0	8.0	195
		20.000	2.0	17.0	196
		25.000	2.0	18.0	201

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Table 2

Exp. no.	Method	Content of components in dispersion (mass %)							R_{res}
		$CaCO_3$	wood pow-der	sur-fac-tant	polymer		alkali		
					name	qty	name	qty	
1	Known	0.1	—	0.5	poly-	0.01	—	—	2.9
2	Proposed	—	0.1	—	acryl-				6.2
3		—	0.3	—	amide				6.3
4		—	1.5	—	poly-	0.10	—	—	6.5
5		—	5.0	—	acryl-				5.6
6		—	6.0	—	amide				4.7
7		—	0.1	—					5.8
8		—	0.3	—					6.4
9		—	0.4	—	polyoxy-	1.00	—	—	6.5
10		—	1.5	—	ethylene				6.5
11		—	5.0	—					5.4
12		—	6.0	—					4.9
13		—	0.1	—					5.9
14		—	0.3	—					6.3
15		—	1.5	—	carboxy-	0.005	—	—	6.4
16		—	5.0	—	methyl				5.9
17		—	6.0	—	cellulose				5.5
18		—	0.1	—					4.9
19		—	0.3	—					5.1
20		—	1.5	—		—	sodium hy-	0.05	5.3
21		—	5.0	—			droxide		4.7
22		—	6.0	—					4.2
23		—	0.1	—					4.9
24		—	0.3	—					5.3
25		—	1.0	—			sodium	20.0	5.7
26		—	1.5	—		—	silicate		5.6
27		—	5.0	—					5.2
28		—	6.0	—					4.8
29		—	0.1	—					4.5
30		—	0.3	—					5.4
31		—	1.5	—		—	Potassium	3.0	5.7
32		—	5.0	—			hydroxide		4.6
33		—	6.0	—					4.3

Claims

1. Method of producing crude oil, comprising injecting a formation with a dispersion of solid particles in an aqueous solution of a chemical reagent, **characterized by the fact** that wood powder is used for the solid particles, and a polymer or alkali is used as the chemical reagent.

2. Method according to Claim 1, **characterized by the fact** that the wood powder is used in an amount constituting 0.3 - 1.5% of the total mass of the dispersion.

3. Method according to Claim 1, **characterized by the fact** that polyacrylamide or polyoxyethylene or carboxymethyl cellulose is used as the polymer, in a concentration of 0.005 - 1.0%.

4. Method according to Claim 1, **characterized by the fact** that sodium hydroxide or sodium silicate or potassium hydroxide is used as the alkali, in a concentration of 0.05 - 20.0%.

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Research and production association "Poisk" of Rospatent
113035, Moscow Zh-35, Raushskaia nab. 4/5

Production and publishing combine "Patent", Uzhgorod, ul. Gagarina 101